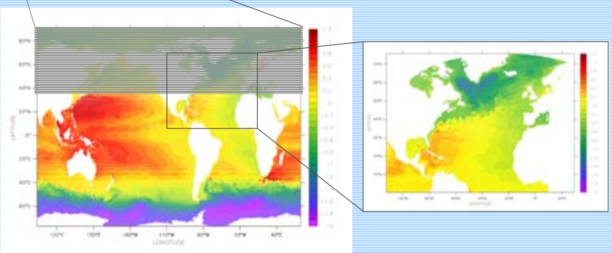
IFM-GEOMAR
Leibniz-Institut für Meereswissenschaften
an der Universität Kiel

# Manifestation of long-term Trends of the Thermohaline Circulation in Sea Surface Height and Ocean Bottom Pressure Fields – Results of a Model Process Study –

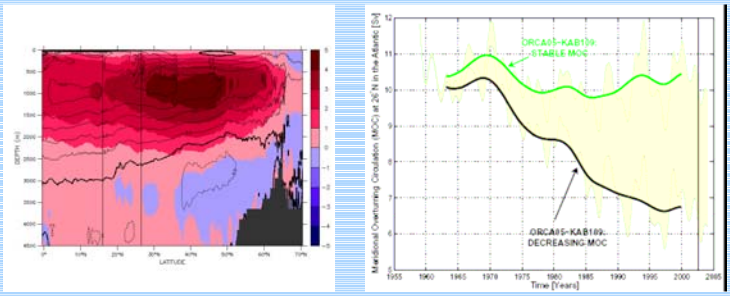
Katja Lorbacher and Joachim Dengg, IFM-GEOMAR, Kiel

## Ocean Model and Runs

- The ocean model used is a global configuration of the oceansea ice model NEMO on an ORCA grid with a horizontal resolution of nominal 0.5° and 46 vertical levels for the period 1958 to 2004. The effective resolution, which gets finer with increasing latitudes, is 60km at the equator and 30km at 60°S or 60°N. It uses the global forcing data set „CORE" (based on a blend of atmospheric reanalysis data and satellite products for 1958 and 2000 (Large and Yeager, 2004)) and applies a bulk forcing methodology.
- The 2 experiments at our disposal, „SALTY"(KAB109) and „FRESH"(KAB110), differ only in the conditions of external freshwater forcing: For SALTY the precipitation northward of 30°N is smaller.
- The snapshot in February 2000 (SALTY) of deviations of sea surface elevation from the global mean (in m) shows areas of deep convection – associated with minima in the sea level – in the Labrador and Irminger Sea (right).
- Furthermore we focus on the North Atlantic region (left).

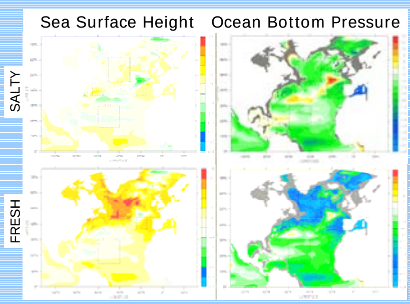


## Long-term Trends of the Thermohaline Circulation ...



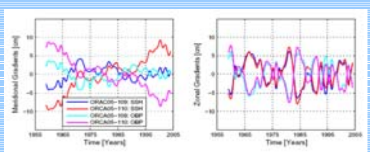
- Annual mean differences of the streamfunction of the meridional overturning circulation (MOC) are around 5Sv at most while the general structure – maximum transport between 30°-40°N at 1000m depth – does not change significantly (left) .
- Time series (interannually and decadally smoothed (23 and 121 month Hanning filter, respectively) of the MOC at 26.5°N show interannual variability with amplitudes around 2Sv; while the MOC in SALTY (green) remains almost stable over the five decades, the MOC in FRESH (black) exhibits a 50% (~5Sv) reduction (right) .
- Vertical lines (left) indicate hydrograhic sections and mooring arrays. For analyses of these data with respect to oceanic mass transports we refer to the poster contribution of U. Neumann et al.

## ... Sea Surface Height and Ocean Bottom Pressure

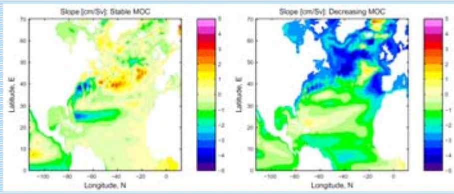



- Differences between the 5th and 1st decade (1996-2004 minus 1960-1968) of SSH (in cm, left) and ocean bottom pressure (equivalent water thickness, in cm, right) reflect the interannual and decadal evolution of the MOC variability (upper panels: SALTY, lower panels: FRESH) .
- Since we removed a global mean of the parameters the changes are mainly due to a strong mass loss in the subpolar North Atlantic.

- Time series of meridional and zonal gradients (between the boxes of the figure above) of the corresponding parameters support the large trend in meridional mass loss.

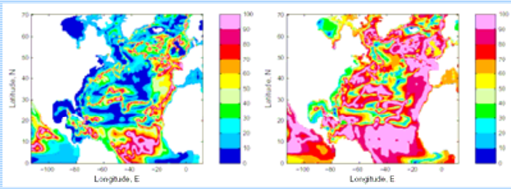


## Some Statistics



- The linear regression between SSH and the MOC (in cm/Sv) of monthly mean anomalies (climatological seasonal cycle removed) in SALTY (right) ranges mainly between -1.5 and 1.5 cm/Sv while the one in FRESH (left) is negative throughout the basin with amplitudes up to 4.5cm/Sv.
- Correlations (also between bottom pressure and the MOC) give similar results.

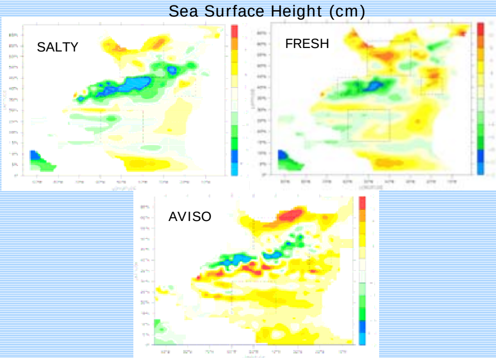
- First analyses of a trend-induced correlation between SSH (bottom pressure) and the MOC indicate that in FRESH (left) the trend explains basin-wide above 80% of the correlation. In SALTY (right) the trend-contribution amounts only to 10% northward of 20°N.



Percentage contribution of the trend to a correlation:
|cov(trend(x1),trend(x2))|/(|cov(x1',x2')|+|cov(trend(x1),trend(x2))|)*100.

## Short-term Trends (1993 to 2004)

Sea Surface Height (cm)




- SSH differences of annual means (2004 minus 1993) show similar spatial structures independent from the analysed data set (upper left: SALTY, upper right: FRESH and lower middle: AVISO product).
- Consequently, a comparison of ten year differences seems to not allow a conclusion on the tendency of a long-term trend of the MOC.

## Outlook

- In our future work we would like to infer the MOC variability from SSH and bottom pressure data and quantify to which amount altimetry and GRACE products are able to detect the interannual to decadal variability of the thermohaline circulation in the North Atlantic.

Contact: klorbacher@ifm-geomar.de or jdengg@ifm-geomar.de